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ABSTRACT

The purpose of this paper is to provide a brief review and assessment of the status of research in science classroom interaction and teacher and student behavior, and to provide recommendations concerning science classroom interaction research and practice. Twenty recent science classroom behavior and interaction studies are reviewed. Flanders-based studies were reviewed by Evans for this symposium (National Association for Research in Science Teaching Symposium, 1970) and have not been included here. A discussion and appraisal of the status and findings of science classroom interaction focused on the following aspects: the number of studies and the classroom setting, theoretical framework; teacher effectiveness, verbal and nonverbal behaviors; similarities and differences in behaviors and interaction; the nature of science; and training and education of science teachers and behavior change. Twelve recommendations concerning these aspects were made. (Author/PR)

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Review, Appraisal, and Recommendations Concerning Research on Classroom Behavior in Science

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Introduction

A major trend in educational research during the past decade was the study of teacher behavior, teacher effectiveness, and classroom interaction. To some extent, this trend was also in evidence in science education as some researchers studied teacher and student behaviors and interaction in science classrooms. Through the services of the Science Education Information Analysis Center, several reviews of recent research in science education became available. Blosser and Howe (13) focused attention on research related to the education of secondary school science teachers and also on research on elementary science teacher education (14). Ramsey and Howe (59, 60) reported on research on instructional procedures in secondary school science. The contents of these recent reports confirm that attention has been given in science education to instructional procedures and behaviors of science teachers.

The purpose in this paper is to is to provide a brief review and assessment of the status of research in science classroom interaction and teacher and student behaviors. A second purpose here is to provide recommendations concerning science classroom interaction research and practice.

No attempt is made herein to provide a comprehensive review and appraisal of all the research on teacher behaviors, teacher effectiveness, and classroom interaction. This would be a task well beyond the scope or intent of this symposium, and numerous excellent reviews are already available in the literature (10, 11, 16, 24, 26, 27, 46, 47, 48, 61, 63, 67, 68, 69).

The most widely used system for the analysis of classroom interaction is the Flanders system for interaction analysis. In science education, numerous studies have also utilized this system. A review and assessment of this aspect of classroom interaction research in science education has been prepared for this symposium by Evans and is not directly addressed in this paper.

A survey of the research in science education reveals that numerous recent studies have continued to focus on comparisons of teaching methodologies and their effectiveness. Some studies also have continued the effort of research on relationships between teacher characteristics, traits, or personalities and effectiveness. Except where such descriptions arise from an analysis of behaviors, they are not reviewed in this paper.

Finally, no attempt is made here to provide an in-depth analysis of research designs and methodologies, although such an effort appears

to be needed in science education. A review and appraisal concerning the overall status and findings of science classroom interaction studies is the primary task that has been undertaken.

The classification of the reviews in the following section is for convenience only. Quite obviously, the studies could also be grouped in numerous other ways.

Studies of Classroom Behavior in Science

Studies utilizing indirect means of data collection

Kochendorfer (38, 39) studied the classroom practices and teaching rationale of high school biology teachers using various curriculum materials. The determination of classroom practices used by the teachers was accomplished through completion of the Biology Classroom Activity Checklist (BCAC) by the students in one of each of the teacher's classes. The BCAC was designed by Kochendorfer for the purpose of determining the extent to which a teacher's practices conformed to the practices recommended in the BSCS literature and by a panel of persons associated with BSCS objectives.

Three groups of teachers were involved in the study. One group consisted of experienced teachers who were using BSCS for the first time, one group consisted of experienced teachers using high school biology texts other than BSCS, and the other group was composed of teachers using BSCS materials and having a mean of five years of experience in the use of BSCS materials. Kochendorfer reported that there was a significant relationship between the mean scores of each teacher on the classroom and laboratory portion of the BCAC, and that there were significant differences among the three groups of teachers in terms of BCAC mean scores. He also reported finding a significant relationship between BCAC scores and Attitude Inventory scores as well as between BCAC scores and "adjusted class mean gains" on the Processes of Science Test. The Attitude Inventory was an instrument designed to determine a teacher's attitude toward BSCS rationale. The Processes of Science Test was an instrument designed to determine a student's understanding of the nature of the scientific enterprise.

Barnes (9) studied the nature and extent of laboratory instruction in high school biology classes using various materials. An instrument was developed which was used to identify the degree to which the laboratory activities of the groups under study conformed to the laboratory activities recommended by the BSCS. The groups under study consisted of classes of teachers who had used BSCS for five years, those using BSCS materials for the first time, and classes using non-BSCS materials.

The instrument, called the Biology Laboratory Checklist (BLAC), was validated by utilization of items based on statements by individuals

who participated in the development of the BSCS program and by having each item verified by a panel of judges who were familiar with the BSCS program. The BLAC was administered to the students in the classes under study.

Barnes found a significant difference among the three experimental groups in degree of conformity of laboratory practices to those laboratory practices recommended by BSCS. He reported also a significant relationship between the degree to which laboratory activities conform to those recommended by the BSCS and the laboratory facilities available. A significant relationship between the degree to which laboratory activities conform to laboratory activities recommended by the BSCS and the degree to which there is teacher acceptance of BSCS objectives was also identified (45).

Studies of questioning behavior

Kleinman (35, 36) has done a study pertaining to the kinds of questions asked by teachers. Her main purposes in this study were to ascertain the kinds of questions asked by general science teachers, to determine the relationship to students' understanding of science, and to determine the relationship to pupil and teacher behavior.

The observation form contained seven question categories and also a listing of bipolar adjectives used in describing teacher and pupil behavior. These four pupil behaviors and eighteen teacher behaviors were rated on a five-interval scale from low to high. Pupil behaviors given were: (1) Apathetic-alert, (2) Obstructive-responsive, (3) Uncertain-confident, (4) Dependent-initiating. Teacher behaviors listed were: (1) Partial-fair, (2) Autocratic-democratic, (3) Aloof-responsive, (4) Restricted-understanding, (5) Harsh-kindly, (6) Dull-stimulating, (7) Stereotyped-original, (80 Apathetic-alert, (9) Unimpressive-attractive (10) Evading-responsible, (11) Erratic-steady, (12) Excitable-poised, (13) Uncertain-confident, (14) Disorganized-systematic, (15) Inflexible-adaptable, (16) Pessimistic-optimistic, (17) Immature-integrated, (18) Narrow-broad. The categories of "Lower type questions" were: (1) Neutral, (2) Rhetorical, (3) Factual. The "Higher type questions" were: (1) Clarifying, (2) Associative, (3) Critical Thinking, (4) Values.

Students' understanding of science was measured by use of the Test on Understanding Science, Form Jy. Attention was given to the reliability of observers and the consistency of behavior of each of the teachers observed.

Most of the seventh and eighth grade general science teachers from five school systems were observed (twenty-three teachers in all). These were observed once, then the three high teachers and the three low teachers, in terms of the frequency of critical thinking questions asked, were observed twice more.

Kleinman reported that the high teachers asked fewer questions than the low teachers and that they asked significantly fewer rhetorical and factual questions. The high group asked almost four times as many high-type questions as the low group. It was also reported that teachers who asked more critical thinking questions also asked more neutral, clarifying, and associative questions than the others. Only one value question was asked in the thirty-five observations. Kleinman felt her data revealed a relationship between the use of critical thinking questions and the behavior of pupils, and reported also a trend toward higher behavior ratings for the high teachers. It was also concluded that seventh and eighth grade boys and girls of high ability achieved a better understanding of science under teachers who asked critial thinking questions than under those who did not.

Kondo (41) studied the questioning behavior of teachers using SCIS. Four first grade teachers were studied while teaching the same sequence of four SCIS lessons. Relationships among the questioning behaviors of the teachers were studied as well as relationships among behaviors in the different types of lessons.

Behaviors were tape-recorded and analyzed in terms of: (1) Complexity (based on question-response-comment units), (2) Question Type (Routine, Cognitive-Memory, Convergent, Evaluative, or Divergent), (3) Teacher Reaction (to responses or to her questions), (4) Transition Probabilities.

Kondo found that there was a fairly consistent pattern of questioning by the teachers across the four lessons, but that differences in complexity of questioning patterns were relatively striking between individual teachers. Percentages of routine and cognitive-memory questions were found to be influenced by the lesson being taught (but not by whether it was an Invention Lesson or Discovery Lesson) and by how it was approached. The approach was found to have the greatest influence on the types of questions asked. About one-half of all the questions asked were convergent and the percentage was fairly uniform across all the lessons. The relative frequency of evaluative questions was low in all lessons, as was the percentage of divergent questions, although the latter were highest in invention lessons. Teacher reactions were found to differ vastly between individual teachers.

Snyder (66) studied verbal question asking as a method of inquiry. One hundred and fifty gifted seventh and eighth grade students and their five science teachers were studied. Subject matter content, training of teachers in the use of the content materials, and ability and grade level of the pupils were controlled.

Oral questions were tape recorded in class and transcribed. Written questions were obtained by having students write questions on 3 x 5 cards at the end of each class day during the data-collection periods.

Based on the proportions of the kinds of questions asked, comparisons were made of the teachers, classes of students, teachers as a group and students as a group, and individual teachers and their specific classes.

It was found that teachers exhibited similarities as well as differences in questioning behaviors and that there were considerable changes in teacher behavior from one unit to the next. However, individual teacher behavior changes showed no consistent pattern from unit to unit, nor did individual class behavior changes. Teachers were found to be similar in the relative usage of different categories of questions. Differences in questioning between different classes of students were less great than differences between teachers. Snyder found no consistent similarities in teacher behaviors and class questioning behaviors.

A fourth study concerning classroom questioning behavior reviewed in this report is the study by Wilson (74). However, since it is also a study comparing behaviors of teachers trained in SCIS with those of more textbook oriented, traditional teachers, this review has been placed with the other studies on "Teacher training and behavior."

Studies with cognitive or structural emphasis

Gallagher (28) studied teacher variation in concept presentation utilizing only biology teachers who taught classes of high ability students using the BSCS Blue Version, Molecules to Man. All teachers were working in suburban situations and all had some training contact with the BSCS program. Furthermore, the study was focused on the concept of photosynthesis, thus attempting to control possible differences in teacher and student behavior that might be the result of the particular concepts being taught.

Gallagher's study was of a cognitive orientation with emphasis with respect to teacher behavior on such aspects as goals, level of conceptualization, and style of presentation. Goals were considered as either content or skills and the levels of conceptualization defined and studied were: (1) Data, (2) Concept, (3) Generalization. The style was considered to be (1) Description, (2) Expansion, (3) Explanation, (4) Evaluation-justification, (5) Evaluation-matching. In addition, Gallagher studied the number of topics covered by each of the teachers in the area of photosynthesis and nature of the attention paid to the textbook.

From an operational standpoint, the data suggested that there was no such thing as a BSCS curriculum presentation in the schools, but rather individual teacher interpretations of BSCS. Gallagher found substantial differences among teachers with respect to "goals" and percentage of "skill topics" treated. He found a highly significant

difference among teachers with regard to the level of abstraction. In the dimension of style, a fairly common pattern was revealed with a great emphasis on topics in the areas of "Description" and "Explanation." Few topics dealing with evaluation or decision-making of any sort were found.

A wide diversity of topics was considered by the teachers in this study, though the content under consideration was chapter nine of Molecules to Man in all cases. Gallagher concluded that each teacher will plan the strategy of presentation and the emphasis on the basis of his own knowledge, interests, and perceptions of student need regardless of how the materials are organized and presented in a formal sense.

Gallagher studied also percentage of teacher and pupil talk, student performance, and student expressiveness. He reported that teachers talked about three to four times as much as students. He found a significant difference among teachers in amount of teacher talk per class, but concluded that teachers generally kept the same proportion of teacher-student talk regardless of the type of topic discussed.

The staff of the Mid-continent Regional Educational Laboratory (McRel) have been involved in an effort to define inquiry and to prepare an instrument for classroom analysis of inquiry behaviors (49). The instrument, Cognitive Operations Monitored In the Classroom (COMIC), was planned to provide an indication of the cognitive nature of inquiry activities, and has been used in conjunction with Flanders system of interaction analysis.

Regarding development of the COMIC, McRel staff identified such askpects as assumptions, purpose, restrictions imposed on categories, rationale for the categories, and bases for classifying verbal behaviors of inquiry. The bases for classifying were logical content, temporal referrant, and context.

A three-second time interval was used, and the COMIC and Flanders interaction analysis were used simultaneously. The categories were as follows: (-) Unclassified Inquiry Statements: The "Blank" Category, (1) Statements of Facts and Information, (2) Statements of Relationships, (3) Verbal Predictions or Plans, (4) Statements about the Function of a Method of Logic or a Thought Product, (5) Verbalized Decision or Collective Judgement of a Group or Teacher, (6) Verbally Expressed Procedural Steps and Methods, (7) Statements of Sensory Observations, (8) Statements Unrelated to the Problem. Numerous ground rules to be used while coding teacher-pupil verbal behaviors with COMIC were provided.

Recent conversations with Dr. Richard Bingman of the McRel staff and additional materials provided by him indicate that revision of the coding system is currently taking place. The coding system now involves

three major columns. The first is very similar to the categories of the Flanders system of interaction analysis. Column Two has student counterparts to the teacher behavior categories of Column One plus: (8) Decision by Class Groups or Teacher, (9) Non-inquiry Talk by Class Members (Pupil or Teacher). The behaviors of Column Two are regarded as social-affective events. Column Three, dealing with cognitive events, is now made up of the following categories: (1) Factual Information or Single Idea, (2) Comparisons and Generalizations, (3) Predicting and Planning, (4) Inquiry into Inquiry Operations, (5) Inquiry into Inquiry Attitudes, (6) Present Procedures to Obtain Knowledge, (7) Sensory Observations, (8) Formulating Question or Discrepant Event, (9) Assessing Content, Goal, or Procedure. The categories of Column Three constitute a revision of the categories of the initial instrument listed previously. There are three special categories as follows: (1) Pupil Exchange, (2) Silence or Confused State, (3) Disruption. Revision of the instrument is continuing.

Moore (50) studied teacher and pupil verbal behavior and teacher procedural and evaluative behavior in relation to objectives unique to the PSSC and the non-PSSC curricula. Two sets of objectives were selected: one set consisted of those objectives unique to the PSSC curriculum, and the other set was composed of those unique to the non-PSSC curriculum. A model of teacher behaviors consistent with a given set of objectives was then developed for each set of objectives. Instruments for the recording of teacher and pupil verbal behaviors and teacher scheduling and testing techniques were then prepared on the basis of these models. The instruments were then used for the recording of teacher and pupil behaviors in classrooms in which one or the other of the two types of curricula was being used. Some data were obtained live, and some were obtained by use of audio tapes.

Encoding was accomplished by use of a multiple sequence category system which consisted of four columns of categories relating to the following: (1) Class Orientation, (2) Speaker and Type of Communication, (3) Content or Goal of the Communication, (4) Orientation to the Two Sets of Curriculum Objectives. Five-second intervals of time were used, and single-digit numbers were used to denote each column of the instrument. Moore stated that separate instruments were developed for teacher nonverbal scheduling and testing techniques. The scheduling behavior instrument was completed from teacher interviews.

Ten physics teachers, five of whom were using PSSC materials and five using non-PSSC materials, were observed five class periods each. Seven laboratory sessions were included in the total.

Moore reported that in non-PSSC classes, 22% of all class time was devoted to teacher and pupil verbal behaviors consistent with non-PSSC objectives, while behaviors consistent with PSSC objectives accounted for 3% of the class time. In PSSC classes, 27% of the time was given to behaviors consistent with PSSC objectives and 8% to behaviors consistent with non-PSSC objectives. In non-PSSC classes, silence or confusion accounted for 16% of the class time; in PSSC classes, it was 13%.

Teacher or pupil verbal behaviors presumably consistent with both sets of objectives accounted for nearly 59% of the class time in non-PSSC classes and nearly 52% of the class time in PSSC classes. Teacher talk accounted for 70% of the time in non-PSSC classes and 69% in PSSC classes. Pupil talk accounted for 14% of the time in non-PSSC classes and 18% in PSSC classes. In both groups of classes, teacher stating, asking for, or answering with a fact accounted for over 50% of the class time. Moore reported that all the non-PSSC lab sessions were used for verification, and that three of the four PSSC labs were used for inquiry. 51% of the non-lab time in non-PSSC classes was devoted to lecture, demonstration, and factual recitation, while in PSSC classes, the figure was 46%. Moore reported that in PSSC classes, the demonstrations were aimed at discovery to a greater degree than in non-PSSC courses.

Communications and interpersonal needs

Friedel (25) developed an observational procedure for describing teacher and pupil verbal and nonverbal classroom behavior. The behavioral record was obtained through the use of video tape equipment and direct observation of thirteen classroom science teachers. The instrument was developed from narrative records of behaviors and a theoretical framework based on a model of communications and a theory of interpersonal needs. Encoding of behaviors was accomplished by recording symbols every five seconds to indicate: (1) Sender, (2) Direct or Indirect Message behavior, (3) Channel, (4) Receiver.

Sender categories described whether messages were sent by teacher, pupil, pupils, or audiovisual device. Twenty-nine categories described direct message behavior and five categories described indirect message behaviors. Channel categories expressed whether behaviors were verbal, nonverbal, or verbal and nonverbal. Receiver categories indicated whether the receiver of the message was teacher, pupil, or pupils. For each direct message behavior, four symbols were recorded—the sender, the direct message, the channel, and the receiver. Indirect messages required three symbols—the sender, the indirect message, and the channel. Five-second time intervals were used.

Discovery and problem solving

Esler (19) described preliminary findings of a study in progress designed to ascertain differences between old and new curricula. Four teachers were involved, of which two were CHEM Study teachers and two were described as participating in "intermediate" and comparatively "traditional" programs. To categorize classroom activity, Esler devised a classification scale based upon the extremes of the discovery approach and the didactic approach. These approaches were operationally defined in terms of types of behaviors of the learner and the teacher. Topics

of classroom activity (of which twenty to twenty-five were found in a forty-two minute class) were assigned a total of five points to be distributed in some way between the two approaches. For each topic, activities were apparently described in behavioral terms along with the distribution of points.

Esler reported that the average percentage of discovery of all the CHEM Study classes observed was about 54% while it was about 8% for the non-CHEM Study classes. Observer agreement and reliability data and procedures were not discussed in the report.

Smith (65) developed an observational system based on a model of experimental problem solving behavior which in turn was based on Piaget's description of such behavior. The system included nonverbal behavioral categories. It was used in a study of the relative effectiveness of external reinforcement and conflict in developing the ability to separate variables in fifth and sixth grade children.

Smith reported that the data revealed changes in teacher behavior patterns unnoticed by the teachers. Ability to separate variables was measured by testing, but the data indicated when the learning took place, what activities preceded such learning, and how consistently the new behaviors were maintained.

Studies of student
verbal behavior

Ferrence (21) developed a technique for quantifying and qualifying student verbal interaction in the laboratory. Attention was focused on students working in small groups in biology laboratories.

The categories of the instrument (Laboratory Interaction Analysis Instrument) were as follows: (1) Questions-Terminology, (2) Questions-Procedure, (3) Questions-Observation, (4) Discussion-Terminology, (5) Discussion-Procedure, (6) Reading, (7) Assignment of Tasks, (8) Negative Answers; (9) Irrelevant Discussion, (10) Teacher Talk, (11) Silence.

Verbal discourse of 75 small groups was recorded on magnetic tape, which in turn was analyzed by use of the instrument by the investigator. Written group reports were evaluated by five experienced biology teachers, the total scores being considered a measure of task orientation for that particular student group. A Spearman rho was used to determine correlations between task orientation and percentages of interaction classified under each category of the instrument, and also between task orientation on day one and day two.

Ferrence reported reliable use of the instrument by trained observers and reliable evaluation of group reports by the teachers. He found significant positive correlations between task orientation and Teacher Talk, Questions-Procedure, and Discussion-Procedure. Other

significant positive correlations were between Discussion-Observation, Reading, Assignment of Tasks, Irrelevant Discussion, Teacher Talk, and Silence on day one and the same categories on day two. A significant negative correlation was found between task orientation and Irrelevant Discussion. No significant correlation was found between task orientation on day one and task orientation on day two.

Multidimensional studies

Balzer (5, 8) and Evans (8, 20) inductively developed an instrument for describing secondary school biology teacher behavior. The intent was to develop a reliable category system based on actual descriptions of teacher behaviors and a method of encoding for systematic observation of biology teacher behaviors. The instrument developed in this manner was then used to obtain an objective description of the classroom behaviors of a sample of biology teachers.

The instrument (Biology Teacher Behavior Inventory) and the method of encoding were developed from video tape recordings of eleven biology teachers during their regular classroom and laboratory presentations. The tapes were recorded over a two-month interval. Each behavior which influenced the teaching-learning situation was recorded on an individual index card. The cards were then grouped according to descriptive similarity and behavioral intent and, after numerous revisions, were used to identify and define the categories, subcategories, and subdivisions of teacher classroom behavior. The development of the category system thus developed inductively from a narrative list of behaviors to subdivisions, subcategories, and categories, and then to the refinement and completion of the Biology Teacher Behavior Inventory (BTBI).

Symbols representing the appropriate categories, subcategories, and subdivisions were encoded on a Data Record according one of four expressional forms: verbal, nonverbal, congruent, and contradictory. Time intervals of ten seconds were used to condense the massive data resulting from a continuous account of teacher behaviors. Inter-observer agreement was determined by use of the Scott Index of Inter-coder Agreement and was found to be 0.92, based on fifteen five-minute segments drawn at random from the video tapes. Inter-observer agreement was checked again at the midpoint and at the end of data collection and was found to be 0.95 and 0.93, respectively.

The categories of the instrument were as follows: (1) Management, (2) Control, (3) Release, (4) Goal Setting, (5) Content Development, (6) Affectivity, (7) Undecided. Subcategories of management were: (1a) Routine Management, (1b) Laboratory Management, (1c) Study Management. Control, Release, and Goal Setting had no subcategories. Subcategories of content development were: (5a) Teacher Centered, (5b) Student Centered. Affectivity behaviors were classified either as (6a) Positive Affectivity or (6b) Negative Affectivity. Both teacher centered content development and student centered

content development could be classified as: (5-1) Procedures, (5-2) Knowledge, (5-3) Scientific Process, (5-4) Tentativeness of Knowledge, (5-5) Generalizations, (5-6) Articulation of Content, (5-7) Facilitates Communication. Each subdivision could be communicated in the following ways: (a) states, (b) asks, (c) shows, (d) acknowledges, (e) clarifies.

Five video tape recordings were made of each of four BSCS teachers and four non-BSCS teachers over a period of three months. The forty tapes were analyzed using the BTBI and the previously described encoding process. Data were converted to percentages and analyzed in various ways by non-parametric statistical tests.

Data analyses revealed that over 44% of all behaviors encoded were management behaviors, and that almost 50% of all behaviors were content development behaviors. Perhaps the most surprising finding was that the nonverbal form of expression was involved and influencing the teaching-learning situation in over 65% of all the behaviors encoded. Goal Setting constituted less than 1% of all behaviors encoded, while teacher centered content development and student centered content development constituted 47.08% and 2.78% of the behaviors respectively. Knowledge behaviors constituted about 33% of the content development behaviors while about 12% of the content development behaviors were in the scientific process subdivision (about 6% of all behaviors encoded). It was found that these teachers spent an average of about five seconds per class period on student centered scientific process behaviors (7). Behaviors addressed directly to the nature of science were limited to those dealing with the tentativeness of knowledge, which constituted less than 1% of the content development behaviors.

Fischler and Zimmer (23) developed an observational instrument for science teacher behavior. They indicated that the identification of behaviors should be related to the purpose of the observations, which in this case, was the teaching of science to children of different ability levels. They specified that the nature of the way in which children of different ability levels learn helped identify behaviors included in the instrument.

The instrument utilized observation by an eye witness, and it made use of the time unit sampling technique. The instrument was a two dimensional check-off sheet, and observed behaviors (defined in terms of overt action) were recorded in 5-minute time intervals. The authors indicated that the initial instrument was refined on the basis of trial usage.

The instrument, called the <u>Science Teaching Observational Instrument</u>, was constituted of three major parts as follows: (1) Teaching Techniques, (2) Teacher's Questions, (3) Characteristics of Teaching. Teaching-Techniques had five major subdivisions as follows: (1) Teacher Talk, (2) Teacher and Student Talk, (3) Teacher does something as well as talk, (4) Students do something besides discuss with the teacher and answer questions, (5) Purpose of the lesson. Teachers Questions

were classified into 5 types: (1) Recall facts, (2) See Relationships, (3) Make Observations, (4) Hypothesize, (5) Test Hypothesis. Characteristics of Teaching were classified into three groups: (1) Concrete-Abstract (a continuum referring to the method of communication used by the teacher to impart knowledge or understanding), (2) Practical-Theoretical (a continuum having to do with the subject matter taught), (3) Directed-Nondirected (applying only to student activities).

In addition to the above classifications, considerably greater detail was available in each of the areas of Teaching Techniques. Teacher Talk could be classified as: (1) Gives Directions, (2) Introduction, (3) Lecture, (4) Summarizes, (5) Explains. Teacher and Student Talk could be classified as: (1) Recitation, (2) Requests Questions, (3) Discussion. Instances where the teacher did something as well as talk were classified as follows: (1) Uses A-V Aids, (2) Demonstration, (3) Helps Individual Students. Instances where the students did something other than answer questions and discuss with the teacher were classified as: (1) One Student or Small Group to Class, (2) Individual or Group Work, (3) Laboratory Work. Purpose of the lesson could be classified as either (1) Review, or (2) Evaluation.

With respect to "Teaching Techniques," the authors specified that the observer should try to determine which is the dominant technique for a given time interval, and that more than one technique should not be recorded for a given time interval. The exception allowed was when teachers divided the class into groups doing different activities. Numerous specific ground rules for using the instrument were provided. It was found that about two weeks of observing was necessary for proper training of an observer. No data arising from use of the instrument were given in the report.

Parakh (52, 55) carried out an investigation of teacher-pupil interaction in high school biology classes. The principal objectives of the study were to develop a reliable category system for first-hand systematic observation of teacher-pupil interaction in high school biology classes and to describe and analyze the characteristics and patterns of teacher-pupil interaction in those classes.

Data were obtained by means of tape recorder and notes (pertaining especially to the nonverbal behavior) taken by the observer. The category system was then developed from notes, tapes, typescripts, and tapescripts. Parakh stated that the theoretical framework underlying his category system was taken from communication theory and social interaction theory. The classroom communication process was seen as giving and seeking information by teachers and pupils.

The classroom behavior of the teachers was conceptualized along three inter-related dimensions: (1) Evaluative, (2) Cognitive, (3) Procedural. Other dimensions were: (1) Pupil Talk Dimension,

(2) Silence, (3) Not Categorizable. In all, there were forty-five categories and subcategories in the dimensions above. Parakh stated that expressive nonverbal behaviors such as smiles, frowns, grimaces, and gestures were not included except to the extent that they were considered helpful in placing behavior into the categories of the system.

The procedure for categorization was to record the number of the category most nearly represented every five seconds. By recording the numbers in rows, some information about sequence was retained. Categorization was accomplished on the basis of pedagogical function or operation rather than on the basis of inferences about the intentions or motivation of the speaker or actor.

Parakh reported that the end product of the first phase of his study was a highly reliable category system for first-hand systematic observation of teacher-pupil interaction in high school biology classes.

In a second study based upon the study just described and utilizing the instrument developed, Parakh did a description and analysis of teacher-pupil interaction (56). Aspects studied were: (1) Teacher Talk, (2) Teacher's Nonverbal Behavior, (3) Pupil Talk, (4) Teacher's Behavior in the Cognitive Dimension, (5) Teacher's Evaluative Behavior, (6) Teacher's Procedural Behavior, (7) Silent Pauses, (8) Patterns of Interaction, (9) Wide Differences in Teacher-Pupil Interaction. Parakh reported that the "average or composite" teacher talked about 75% of the total class time. With respect to teacher's nonverbal behavior, the principal result reported was that the average teacher's pedagogically relevant non-verbal behavior accounted for about 8% of total time in lectures and 37% in labs. Pupil talk addressed to the teacher accounted for 15% of the total time in lectures and 13% in labs. Pupil responses and information giving constituted 12.4% of the time in lectures and 6.7% in labs. Teacher's evaluative behavior such as praising, encouraging, and accepting student performance and ideas constituted about 7% of the time in lectures and 3% in labs. Parakh stated that pupil questions were seldom if ever praised or encouraged. It was found that about 18% of the time in lectures and 40% in labs was devoted to teacher procedural behavior. Teacher's behavior in the cognitive dimension constituted an average of 54% of the total class time in lectures and 42% in lab. Information giving constituted 43% and 29% as compared with 11% and 13% devoted to information-seeking. Operations within the cognitive dimension that received attention were demonstrations, fact stating, explaining, defining, evaluation, asking for facts, asking for explanations, and asking for definitions. He reported that teachers seldom asked pupils to give opinions, hunches, or evaluations (less than 0.1%) and that explicit references to the nature of science were virtually absent. Parakh noted also that problem-solving behaviors occurred infrequently, comprising only about 0.6% of the time in labs and less than 0.1% in lectures.

Parakh reported that silent pauses made up about 3% of the class time in lectures. Teachers' questions accounted for about 11% of the time in lectures while pauses after the questions accounted for 1.2% of the total time.

Patterns of interaction in lecture-recitation classes were found to be constituted mostly of four categories which accounted for 55% of the total interaction. Descriptively, this pattern was as follows: The teacher gave information, the teacher asked a question, the pupil responded briefly, and the teacher accepted the response or indicated that it was correct. Several variations of the above pattern were also reported by Parakh. In laboratory classes, a larger variety of interaction patterns was found, with teacher behavior seen as largely responsive to pupil requests for information and materials. In addition, Parakh reported wide differences in interaction scores among the ten teachers.

Perkes (58) reported a study of junior high school science teacher preparation, teaching behavior, and student achievement. The subjects of the study were 32 teachers and 3062 students enrolled in general science. Background information about the teachers was obtained from the school records. Their behaviors were recorded by trained observers using the <u>Science Teaching Observation Instrument</u> (STOI). Student achievement was measured by administration of two tests near the end of the school year, the <u>Sequential Test of Educational Progress: Science Test Level Three</u> (STEP), and the <u>Junior High School Science Achievement Test</u> (JHSSA). Correlations between the variables were considered significant at the .05 level.

Perkes reported that the number of academic credits in science did not correlate significantly with science teaching behavior. However, higher GPA in science, more recent enrollment in a college level science course, and a greater number of units in science education were found to be directly related to: (1) more frequent teacher-student discussions, (2) more frequent student participation in laboratory activities, (3) more frequent use of equipment, (4) a greater use of questions of a hypothetical nature, (5) lessons stressing principles of science, drawing upon social and technological applications for clarification purposes.

Numerous relationships between teaching behaviors and student acheivement were also found. A direct relationship between lecturing, teacher demonstrations, and questions of a factual recall nature and student recall of factual information was reported. There was a negative relationship between the above items and application scores, however. Student involvement in laboratory activities and discussions, frequent use of equipment, lessons stressing principles of science, and questions requiring students to speculate appeared to be highly related to student achievement in applications, and negatively associated with recall scores.

Teacher training
and behavior

Ashley (3) studied the impact of an inservice education program on teacher behavior. The inservice program was designed to enhance teacher behavior in the use of Science - A Process Approach. Ashley hoped to: (1) Identify strategies of teaching which were an integral part of a curriculum sequence emphasizing cognitive behavioral outcomes, (2) Design a Classroom Observation Rating Form (CORF) to sample these strategies, (3) Evaluate the impact of an inservice program on use of these strategies, (4) Analyze teacher attitudes and their relationship to teacher behaviors, (5) Analyze the relationship between years of experience and grade level assignment and teacher behavior.

Twenty-three teachers, representing grade levels one through six constituted the sample. All were enrolled in the inservice program and used Science - A Process Approach materials exclusively as their science program during the 1966-1967 school year. Ashley stated that attention in the inservice program was given to the preparation of individual lessons, to the building of science backgrounds in the processes comprising the sequence, and to highlighting strategies consistent with the rationale of the curriculum sequence. The program began in October, 1966, and ended in April, 1967.

The Semantic Differential was used to ascertain attitudes toward the curriculum, the inservice program, and 10 other concepts and protocol words. The CORF was used to sample the classroom behavior of teachers. The strategies comprising the CORF were obtained from teachers experienced in teaching Science - A Process Approach on the basis of effectiveness and consistency with the program's rationale. Strategies were stated in a bipolar manner, with Behavior A being the more consonant with the rationale of the curriculum and Behavior B constituting the negative counterpart. The categories of the instrument were as follows: (1) Teacher-student Interaction and Student Behavior (student orientation vs. teacher directed), (2) Teacher Responses and Actions (degree of teacher pattern of sensitivity to student experience, abilities, interests, and thorough planning), (3) Specific and Personal Teacher Traits (pertaining to whether teacher is positive in approach to discipline, self-control, enthusiasm, and knowledge), (4) Physical Aspects of the Classroom Environment (attractiveness and student-centeredness of learning environment).

Trained observers conducted four observations of each of the 23 teachers, three of these observations pertaining to science lessons. The Semantic Differential was administered to the sample of teachers prior to and at the conclusion of the inservice program.

Ashley reported that between the first observation (non-science) and the first science observation, there were significant changes toward

greater use of Behavior A strategies. Between the first science observation and the last science observation, however, there was a decrease in the employment of Behavior A strategies. Overall, between the first observation and the last, there was an increase in employment of Behavior A strategies. He suggested that the teacher group had reached a plateau of strategy use at the time of the first science observation. It was also reported that overall, the CORF change scores correlated negatively with semantic differential scores. In other words, while their attitudes tended to become more positive (as defined), their use of the strategies considered to be positive decreased. The primary teachers achieved more in the use of CORF positive strategies than could be predicted based on total group performance, and the intermediate teachers achieved less than could be predicted. Analysis of years of teaching experience and use of specific teaching strategies failed to provide evidence of a relationship. In conclusion, Ashley questioned the value of using a teacher's attitude as an indicator of actual classroom behavior. He suggested that the inservice program seemed to relate to positive modification of teacher attitude.

Hall (30) studied the teaching behaviors of three groups of second grade teachers, especially the relationship between the curriculum vehicle and the teaching behaviors. The curriculum vehicle utilized in the study was Science - A Process Approach. According to Hall, the questions examined in this study were as follows: (1) If a school system installs a recently developed curriculum, does this curriculum in and of itself influence teaching behaviors? (2) What effect does the method of teacher training and supervision have on the teaching behaviors of teachers teaching a new curriculum?

Groups SuS and InS were teaching Science - A Process Approach for the first time. SuS teachers had a five-day summer workshop and a bi-weekly visiting science consultant throughout the school year. Group InS had inservice sessions during the year before installation of the curriculum, and also received supervisory help from their school system science coordinators. NoS teachers were not trained in teaching a new curriculum and were teaching science programs similar to those taught by SuS teachers in previous years.

The observation instrument used was the Instrument for the Analysis of Science Teaching (IAST), developed by Hall. Part I of the instrument was a 26-category system of interaction analysis, and Part II was a 15-item sign system to be completed by the observer at the completion of each observation period.

Hall reported that the SuS teachers differed significantly from the NoS teachers in their use of more teacher and direction statements, student overt activity, teacher talk per amount of student talk, and teacher closed questions per number of open questions. He reported that the InS teachers differed significantly from the NoS teachers in their use of more teacher and direction statements, student overt activity, and direct motivation and control teacher behaviors. Both the SuS and InS groups differed significantly from NoS teachers in

their use of fewer student open statements, extended student talk per amount of transition student talk, and extended student talk per total amount of student talk. SuS teachers also differed from the NoS group in their use of significantly fewer teacher open questions than NoS teachers. InS teachers differed significantly in their use of fewer student close statements than NoS teachers.

The two principal conclusions drawn by Hall were: (1) Teachers teaching Science - A Process Approach have some different teaching behavior from teachers not teaching a recently developed science curriculum. (2) The five-day summer workshop and biweekly visiting science consultant were more effective than in-service training during the school year and supervisory help from the K-12 school system science coordinator.

Hunter (32) studied the verbal behavior of first grade teachers as they taught science. Eleven of the teachers had participated in a training program in one of six new elementary school science programs; the other eleven teachers (control group) were selected so that the classes matched the experimental group in ability levels. Each teacher was observed on two separate occasions.

The instrument used to observe verbal behavior was the Revised Verbal Interaction Category System (Revised VICS - Science). The categories of the instrument were as follows: (1) Lecture, (2) Directions, (3) Questions, (4) Praise, (5) Acceptance, (6) Rejection, (7) Response to teacher, (8) Response to Pupil, (9) Initiation to teacher, (10) Initiation to Pupil, (11) Pupil Talk while using Materials, (12) Silence, (13) Silence while using Materials, (z) Confusion. Questions were classified as: (a) Cognitive Memory, (b) Convergent (c) Divergent, (d) Evaluative. Praise behaviors and rejection behaviors were categorized as: (a) No Reasons, (b) Personal Reasons, (c) Rational Reasons. "Response to teacher" behaviors were either (1) Predictably, or (2) Unpredictably.

Hunter reported that pupils of teachers in the experimental group used materials to a greater extent than pupils of teachers in the control group. She reported also that there was nearly three times as much discussion while using materials in the experimental classes as in the control classes. It was suggested that this was probably due to a greater availability of materials. It was also reported that teachers in the experimental group spoke significantly less than teachers in the control group, and that pupils in the experimental group spoke significantly more than those in the control group. In all other respects studied, including the verbal patterns of teachers and pupils, the two groups did not differ significantly.

Hunter reported that pupils worked silently with the materials only about 1% of the time. Although teachers spent about 40% of their talk time asking questions, about 95% of all questions asked were

of the cognitive memory type, compared with 0.4% evaluative and 0.4% divergent. Praise was used about 4% of the total class time, and almost 98% of the praise statements were given without reasons. Most rejections (about 5% of the class time) were also given without reasons. Teacher acceptance statements constituted about 8% of the class time. Pupil-initiated talk to other pupils (except while using materials) constituted 0.02% of the class time.

Hunter concluded that since training verbal interaction skills has been known to change the verbal behaviors of teachers, it should be included in curriculum materials training sessions if authors and publishers of programs desire that certain kinds of thinking take place.

In a study of SCIS and non-SCIS teachers, Wilson (74) focused on questions being asked by teachers. Wilson emphasized the importance of the kinds of questions being asked and suggested that the art of questioning is the essence of discovery teaching.

Thirty teachers were studied, one-half of them having been trained in the use of the SCIS approach. The matching group had not received training in any of the "new" science projects, were strongly textbook oriented, and did not espouse the inquiry-discovery approach.

The instrument used for classification of teacher questions was the Teacher Question Inventory by McIntyre and Harris (31). The instrument enables classification of questions on a hierarchial order derived from the Taxonomy of Educational Objectives.(12). Questions were classified as: (1) Recognition, (2) Recall, (3) Demonstration of Skill, (4) Comprehension, (5) Analysis, (6) Synthesis. Wilson stated that all the questions of a cognitive nature asked by the teachers during the science lessons were applicable to one of these six categories.

Wilson found that the lower level questions (recognition, recall, and comprehension) were recorded a significantly larger proportion of times for the traditional science teachers group than for the new science teachers group. Higher level questions (analysis and synthesis) and demonstration of skill questions were recorded a significantly larger proportion of times for the new science teachers group. In addition, Wilson reported that the new science teachers asked 49% more questions in general than the other group.

Discussion

The studies reviewed in this report are listed in Table I. Each study has been associated with a descriptive phrase and a school setting. In cases where certain curriculum materials were associated in some way with the study, this has also been specified.

TABLE I

A LISTING OF CLASSROOM BEHAVIOR AND INTERACTION STUDIES IN SCIENCE[a]

Research Description	Researchers	School Setting
Studies utilizing indirect source of data		
	Barnes	high school biology (BSCS)
	Kochendorfer	high school biology (BSCS)
Studies of questioning behavior		
	Kleinman	7th-8th grade gen. sci.
	Kondo	1st grade (SCIS)
	Snyder	7th-8th grade science
Studies with cognitive or structural emphasis		
	Gallagher	high school biology (BSCS)
	McRel	high school biology (BSCS)
	Moore	high school physics (PSSC)
Discovery and problem solving		
	Esler	high school chemistry (CHEMS)
	Smith	5th-6th grade science
Communications and interpersonal needs		
	Friedel	high school science
Student verbal behavior		
	Ferrence	high school biology
Multidimensional studies		
	Balzer and Evans	high school biology (BSCS)
	Fischler and Zimmer	jr. high school science
	Paralch	high school biology (BSCS)
	Perkes	jr. high school science
Teacher training and behavior		
	Ashley	elementary science (S-APA)
	Hall	2nd grade (S-APA)
	Hunter	1st grade (various curr.)
	Wilson	elementary science (SCIS)

[a]Excluding studies based on the Flanders system of Interaction Analysis.

The discussion which follows is intended as an appraisal of the overall status and findings of the preceding reviews. It is not intended as a specific, critical analysis of individual research designs and methodologies. Various more specific theoretical and methodological considerations are being discussed in this symposium by Parakh.

The number of studies and the classroom setting

Perhaps the most obvious observation is that science teacher behavior and classroom interaction studies still are not numerous. Six studies pertained to science in the elementary school, four pertained to science in the junior high school, and ten studies focused primarily on the senior high school, though some of these also involved ninth grade science. Of these ten high school studies, seven concentrated on biology classrooms and teachers. One of the studies used physics classrooms, and one involved chemistry classrooms and teachers. It is thus apparent that science classroom behavior at the various levels of public instruction has been very lightly researched, though high school biology, especially BSCS biology, has received more attnetion than the other areas. Though various of the research techniques and products very likely are applicable to science teaching at any level, the above observations are pertinent in that descriptive information concerning science classroom interaction for particular ages and developmental levels of children is limited. We need more studies describing classroom interaction under various conditions, especially in elementary schools, middle schools, and high school physical and earth science courses.

This early developmental stage also has research methodology implications. Medley (48) suggested the need for extensive status and survey studies as a basis for theory building concerning teaching. Our experience in science supports the suggestion that extensive descriptive information is needed for intelligent hypothesis generation.

Theoretical framework

A survey of the research literature revealed also that studies often have not proceeded from a broadly based theoretical framework. Five studies clearly specified a theoretical framework, but the rest did not. The call for theory and models in science education is not new, but it is still appropriate. Pella (57) suggested in 1966 that science education was at a stage when its concepts were indefinite and that descriptions and operational definitions relating concepts to sensed data were badly needed. The difficulty of developing theoretical structure (even though tentative) in science education is thus quite understandable. The need, however, continues to be evident. The observation of Tyler (72) that conceptions of maps of the terrain that are employed in science education research are often not explicitly stated, though it is possible to tease them out, also appears to apply here.

Some of the writers imply such conceptions but do not make them explicit.

Several considerations should guide the researcher interested in instrument development for the analysis of classroom behavior and interaction. First, we must continue to draw upon various disciplines as sources of models. Second, there must be a clear distinction between adopting the theoretical formulations of other researchers for convenience and the selective utilization of only those with convincing contributions in science education. Third, the researcher must ask whether or not there are additional components within the domain of science education which are of unusual implication to the science classroom. Only a few of the studies reviewed show evidence of being based even partially on theoretical formulations of special, if not unique, concern in science education.

Some of the areas in which models for classroom interaction might be developed are: (1) The nature of science, (2) Processes and skills of science, (3) Scientific attitudes, (4) Scientific literacy or scientific enlightenment, (5) Inquiry, (6) Concept development, (7) Environmental Education, (8) Social responsibility in a technological age, (9) Social implications of scientific knowledge, (10) The new science course improvement projects. Most of these topics have received considerable attention in the recent literature of science education, but models for teacher behavior and classroom interaction research and practice have very rarely been forthcoming. Except for the work of McRel in inquiry (49) the only topic of those listed to receive extensive attention in the research reviewed was the new science course improvement projects. Even here, the research efforts appear to have been more comparative than basic, though the work of Moore (50) seems to have been based on rather fundamental theoretical and methodological considerations. Questions such as the following continue to face us in these and other areas upon which we place emphasis in science education: (1) What, if anything, are teachers and pupils doing in this respect in the science classroom? (2) What does our best thinking suggest that they could (or should?) be doing?

The above discussion suggests the continued need for well-defined deductive studies. That is, we appear to need studies in which the researcher specifies a well-defined theoretical framework and views the classroom interaction in terms of these prior considerations. In the past, some deductive researchers have modified observation instruments on the basis of trial usage in classrooms, thus adapting the instrument to actual classroom situations. The obvious danger of the deductive approach is that it may result in the failure to observe various (perhaps significant) classroom behaviors which are not implied by the theoretical framework. A partial answer to this problem may be provided by the inductive approach proposed and utilized by Balzer and Evans (8). This approach used a general model of scientific research, placing emphasis on empirical data. The effort was to record and encode all classroom behaviors <u>as they occurred</u> without prior decisions concerning a

particular perspective or the exclusion of certain groups of behaviors. A difficulty in this approach is that no observer is able to be strictly empirical in the classification of behaviors; previous experience and biases will enter into the generation of categories from observed and described behaviors. In this sense, then, even this approach is not without an element of deductiveness. Nevertheless, the emphasis here is on obtaining data that is as free as possible from the application of pre-determined criteria.

Teacher effectiveness

Only four of the studies reviewed in this paper reported attempts to assess the effectiveness of teachers in relation to behaviors. Kochendorfer (38, 39) reported a significant relationship between BCAC scores and Attitude Inventory scores and also the adjusted class means on the Processes of Science Test. Kleinman (36) found more critical thinking questions associated with high understanding of science as measured by the Test on Understanding Science. Ferrence (21) found positive correlations between task orientation (as determined by teacher evaluations of pupil written reports) and teacher talk, question-procedure, and discussion-procedure. A negative correlation was found between irrelevant discussion and task orientation. Perkes (58) found a direct relationship between lecturing, teacher demonstrations, and questions of a factual recall nature and student recall of factual information. There was a negative relationship between the above items and application scores. Student achievement in applications was highly related to laboratory discussions and activities, frequent use of equipment, lessons stressing principles of science, and questions requiring speculation.

A generalization based on these results is difficult and perhaps inappropriate. At best , the evidence suggests that higher level cognitive achievement by students may be related to higher level activities and behaviors in the classroom and that lower level achievement and activities may be related. Those especially interested in effectiveness research should also study the paper (in this symposium) by Evans, addressed especially to studies utilizing the Flanders system of interaction analysis. Obviously, more research must be done before we say much with confidence concerning teacher effectiveness in the science classroom. Hopefully, some principles of teacher effectiveness, as they arise from educational research, will also be applicable in the science classroom. However, there are areas (such as effectiveness of instruction in processes of science or scientific attitudes) in which the primary source of information may have to be science classroom research. In any case, it is clear that teacher effectiveness must be considered in relation to quite specific goals and objectives of the teacher. The task of acquiring ample information for science teacher effectiveness thus becomes a complex and many-faceted task, requiring quite precise definition of the goals and objectives in question.

The task is further complicated by the recent evidence (61, 68) that traits which also may show up as categories of behavior in an instrument, are sometimes much too broad, actually containing behavioral components that mask each other. It is another example of our need to obtain information that may not be encompassed by current theory. Soar (68) has suggested the contributions of multivariate statistical analysis in this regard and Balzer and Evans (8) have encouraged the continued use of comparatively inductive studies.

Verbal and nonverbal behaviors

Friedel (25) found that all indirect messages were nonverbal, and that 87% of the direct messages of the classroom were strictly verbal. Parakh (56) reported finding that teachers talked about 75% of the time and that in lecture about 8% of the behaviors were nonverbal, while in lab 37% of the behaviors were nonverbal. Balzer (5) and Evans (20) found that more than 66% of all behaviors included nonverbal components judged to influence the teaching-learning situation.

Numerous early researchers assumed that verbal behaviors constituted an adequate sample of teacher behavior. The above findings cast doubt on the validity of this assumption in science classrooms. While it appears that science teachers talk most of the time and talk much more than the pupils, it also appears that they do very much besides just use oral language. The extent and significance of nonverbal communication in the classroom appears to need much more research.

Similarities and differences in behaviors and interaction

Several researchers reported significant differences among teachers based on behaviors. Kondo (41) reported that differences in complexity of questioning patterns were relatively striking between individual teachers. Snyder (66) found that teachers differed more in questioning behavior than their classes differed in this regard. Gallagher (28) reported substantial differences among BSCS teachers in goals, skill topics, levels of abstraction, teacher talk per class, and content topics on a given subject. He suggested that there was no such thing as a BSCS curriculum in the schools, but rather individual interpretations of BSCS. Balzer (6) found significant differences among individual teacher's behaviors in numerous subcategories and subdivisions of behavior, but not between BSCS teachers and non-BSCS teachers.

Some researchers also reported similarities in teacher behaviors. Snyder (66) reported that teachers were similar in the relative usage of categories of questions. Balzer (6) found a high correlation among teachers in the relative usage of behaviors of various categories, subcategories, and subdivisions of the BTBI. It appears that teachers whose

behaviors are strikingly similar in some respects may be significantly different in other respects, or when behaviors are analyzed in another way. Additional descriptive studies are needed to further identify those respects in which teacher behaviors are similar and significantly different. An adequate answer to the question: "In what respects do we want teacher behaviors to be similar and different?" appears to be much farther away.

Affective and higher level cognitive behaviors

Kleinman (36) reported finding only one "value" question in her study. Gallagher (28) found that description and explanation were the common styles, but found few topics dealing with evaluation and decision-making. Friedel (25) found 31% authoratative information behaviors by teachers compared with 5% experimental information. 1% of the teacher behaviors were positive reinforcement and 1% were negative reinforcement. Esler (19) reported 8% discovery behaviors for non-CHEM Study teachers compared with 54% discovery for CHEM Study teachers. Balzer (5) and Evans (20) found that knowledge behaviors constituted about 33% of all content development behaviors, or about 16.5% of all behaviors. By contrast, about 12.5% of the content development behaviors (or, about 6% of the total) were classified as scientific process behaviors. They found that positive and negative affectivity accounted for 0.53% and 0.84%, respectively, of all the behaviors encoded. Parakh (56) reported that evaluative behavior constituted 7%of the lectures and 3% of the labs. He found problem-solving behaviors to constitute 0.6% of the laboratory behaviors, and 0.1% of the lecture behaviors. Hunter (32) found that about 95% of all questions asked were of the cognitive memory type and that only 0.4% were evaluative and 0.4% were divergent. She found that the teachers used praise about 4% of the total class time, and that 97.7% of the praise statements were given without reasons. Rejection was used about 5% of the class time, and 7.2% of the rejection behaviors were accompanied by rational reasons. Moore (50) reported that the teacher statements of asking for, and answering with facts accounted for over 50% of the time in both PSSC and non-PSSC classes.

The interpretation of the above is quite clear. Except for the two CHEM Study teachers involved in the Esler study, the major emphasis in classes reported on was informational rather than affective or higher level cognitive. Furthermore, it must be pointed out that many of the affective behaviors reported were negative, and that affective behaviors in the classroom may or may not imply affective learnings. If we desire appreciable affective and higher level cognitive behaviors in the classroom, we will have to find and use effective ways of educating or training teachers in their initiation.

The nature of science

Parakh (56) reported that behaviors pertaining to the nature of science were virtually absent. Balzer(5) and Evans(20) found behaviors concerning the nature of science to be limited to references to the tentativeness of knowledge, which constituted less than 1% of the behaviors. From these data, it would appear that very little instruction

specifically pertaining to the nature of science may be taking place in classrooms. The need for additional classroom interaction studies focusing on this major science education concern is apparent.

<u>The training and education of science teachers and behavior change</u>

The four studies reviewed pertaining to this topic were all attempts to identify behavioral differences or changes in relation to science curriculum training programs, summer workshops, or inservice sessions. Some were reporting these differences also in conjunction with differences in curriculum materials being used in the classroom.

Ashley (3) attempted to identify changes in behavior during the course of a <u>Science - A Process Approach</u> inservice program. He found a major increase in the desired strategy use from the first to the second observation and an overall decrease thereafter. He also found a negative correlation between attitudes and the use of strategies considered to be positive. The findings of Hall (30) concerning training in <u>Science - A Process Approach</u> and the use of the materials were descriptive in nature and quite difficult to interpret. To this writer, the findings appeared to be in overall conflict with <u>Science - A Process Approach</u> philosophy. Hunter (32) studied behaviors in classrooms where teachers had been trained in one of six new elementary science programs (and were teaching these programs) and compared these with a control group. Hunter found little difference between the two groups except that the experimental group had more pupil talk, less teacher talk, and greater use of materials by pupils than the control group. Wilson (74) studied the question-asking behavior of SCIS and non-SCIS teachers. The SCIS teachers had been trained in the use of the SCIS approach. The control group had not been so trained, were strongly textbook oriented, and did not espouse the inquiry-discovery approach. Wilson found lower level questions asked significantly more by the control group and higher level questions asked significantly more by the SCIS group.

Hence, the evidence appears to be inconclusive concerning the effects of training programs in the new science programs on classroom behaviors. A clear relationship does not appear to exist either when differences in materials being used constitutes a variable or when it does not. Obviously, more studies pertaining to the relationship between training programs and classroom behaviors are needed.

Probably we will continue to need broad, descriptive studies attempting to describe behaviors under various conditions, including teacher training and the use of various curriculum materials. Such studies are needed to enable us to understand what is actually occurring under given circumstances in classrooms.

It may be, however, that the gross mix of variables in such studies prohibits our learning very much about training programs. Behavior analysis in conjunction with an educational process or training program, if it is to provide information concerning that process or program, should

proceed with maximum control of other variables. Long-range studies of individual teacher behavior change would appear to be a promising approach.

Since there is considerable evidence (32) that behavior change can result from direct teacher training in behavior skills, it seems that researchers and curriculum developers should be encouraged to incorporate such procedures in their studies and plans. This would enable us to learn more about the potential of this direct attack on behaviors in science education.

A word of caution is in order at this point. The above discussion implies the need for statements of desired or of preferred behaviors. As is evident throughout this paper, it does not appear to this writer that we have ample research evidence to enable us to make strong statements about which behaviors are best, or most effective, at this time. We should be willing, however, to attempt to conceptualize, describe, and measure behaviors consistent with philosophy, rationale, and objectives.

Finally, this writer continues to maintain the hope that effective means for facilitating the personal involvement and commitment of the individual teacher can be developed. Perhaps we would find that the behavior training needs of teachers committed to a given philosophy would be very different from a teacher not so committed. The evidence in the Ashley (3) study would seem to indicate that attitudes and behaviors do not necessarily correspond, but the evidence of the Wilson (74) study can be interpreted as preliminary indication that behavioral differences are more likely to arise in conjunction with training and curriculum differences when there are also commitment differences. Certainly, the behavioral differences between the trained and untrained teachers were the most pronounced among the studies of this type reviewed, in the Wilson study, which incorporated a commitment difference. In short, it is hoped that in our concern for teacher behavior training, we will not forget the role that teacher education may play. Teacher education and behavior training should be able to complement each other.

Recommendations

1. More research studies should be undertaken in science classroom interaction at various grade and ability levels. One of the most basic needs continues to be for more extensive descriptive data. We still do not know enough about what happens in science classrooms, and only extensive, objective, descriptive data will resolve this problem.

2. A variety of instruments, creatively developed, are needed. A wide range of models, wisely chosen from various disciplines, should be employed in thier development, and models should be developed in science education for science teacher classroom behavior and classroom interaction. There does not appear to be an instrument that is adequate for

all our research needs at the present time.

3. Inductive and deductive methods of instrument development should be employed, and careful and critical thought should be given to the contributions of each method. One of the strengths of the inductive method appears to be in the provision of an extensive empirical base of data. The deductive method would appear to be more effective in the provision of data concerning specified areas of behavior or in describing behaviors viewed from a specified perspective or bias. For example, the deductive researcher studying inquiry might "find" a behavior in hypothesis formulation which an inductive researcher might have seen simply as scientific process.

4. Through instruments developed as described above, we should describe more fully science classroom behaviors and interaction in such areas as the nature of science, processes and skills of science, scientific attitudes, scientific literacy, inquiry, concept development, environmental education, social responsibility, and social implications of scientific knowledge.

5. Nonverbal behaviors of teachers should be carefully studied in the future rather than ignored or assumed as unimportant. Several recent researchers have found nonverbal behaviors to be prevalent, but additional descriptive information is needed.

6. Similarities and differences in behaviors of individual teachers should be more carefully studied and eventually these data should be related to models and findings concerning effectiveness. Problem areas include whether or not significant individual differences among teachers should be maximized or minimized, and in which respects.

7. We should continue our pursuit of knowledge concerning teacher effectiveness. However, effectiveness is many-faceted and it has become apparent that science educators must come forth with precise statements of desired objectives. There will (and probably should) be a wide range of opinions concerning priorities, but the possibilities must be expressed and related to science classroom interaction.

8. In any given study, effectiveness must be precisely defined. Goals and objectives of the teacher should be clearly incorporated in such definitions.

9. Decisions must be made regarding the frameworks in which facets of effectiveness should be expressed. Examples might include goals and objectives proposed in various curriculum materials, the nature of science, the processes of science, human abilities as classified according the Bloom's taxonomy, and inquiry. It may not be reasonable to expect an adequate volume and quality of effectiveness research on all facets of effectiveness as conceptualized according to all such relevant frameworks.

10. Much more research which describes student behaviors in the classroom should be initiated. Studies by Ferrence (21) and Parakh (53) should be consulted by those interested. An aspect that should be attended to is teacher interaction with individual students.

11. On the basis of the research reviewed in this report, it appears that long-range classroom behavior and interaction research programs still do not exist, with the possible exception of the current works by McRel. Such major, long-term efforts generating classroom data should be undertaken.

12. Additional research studies should be carried out pertaining to teacher training programs. Long-range studies addressed to behavior change in time are needed, especially in relation to behavior and interaction training.

Summary

Twenty recent science classroom behavior and interaction studies were reviewed. Flanders-based studies were reviewed by Evans for this symposium and have not been included here. A discussion and appraisal of the status and findings of science classroom interaction focused on the following aspects: (1) The number of studies and the classroom setting, (2) Theoretical framework, (3) Teacher effectiveness, (4) Verbal and nonverbal behaviors, (5) Similarities and differences in behaviors and interaction, (6) Affective and higher level cognitive behaviors, (7) The nature of science, (8) The training and education of science teachers and behavior change. Twelve recommendations concerning these aspects were made.

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